IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of:	)	
	)	
Fradkin et al.	)	
	)	
Serial No.: 10/535,466	)	Group Art Unit: 2624
	)	
Filed: May 17, 2005	)	Examiner: Sathyanaraya V. Perungavoor
	)	
For: IMAGE PROCESSING SYSTEM FOR AUTOMATIC ADAPTATION OF A 3-D MESH MODEL ONTO A 3-D SURFACE OF AN OBJECT	)	**Board of Patent Appeals and Interferences**
	)	
Confirmation No.: 6154	)	

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REPLY BRIEF UNDER 37 C.F.R. § 41.41

In response to the Examiner's Answer mailed on September 10, 2009, to the Appeal Brief filed June 18, 2009, and pursuant to 37 C.F.R. § 41.41, Appellants present this Reply Brief in the above-captioned application.

This is an appeal to the Board of Patent Appeals and Interferences from the Examiner's final rejection of claims 1-15 in the Final Office Action dated January 21, 2009. The appealed claims are set forth in the attached Claims Appendix.

1. Status of the Claims

Claims 1-15 have been rejected in the Final Office Action. The final rejection of claims 1-15 is being appealed.

2. Grounds of Rejection to be Reviewed on Appeal

I. Whether claims 1, 2 and 15 are unpatentable under 35 U.S.C. § 103(a) over "General Object Reconstruction Based On Simplex Meshes" by Delingette, published in the International Journal of Computer Vision, vol. 32, pp. 111-142, 1999 (hereinafter "Delingette").

II. Whether claims 3-7 are unpatentable under 35 U.S.C. § 103(a) over Delingette in view of U.S. Patent No. 6,968,299 to Bernardini et al. (hereinafter "Bernardini").

III. Whether claims 8-14 are unpatentable under 35 U.S.C. § 103(a) over Delingette in view of Bernardini and U.S. Patent No. 6,201,889 to Vannah (hereinafter "Vannah").

3. Argument

I. The Rejection of Claims 1, 2 and 15 Under 35 U.S.C. § 103(a) over Delingette Should Be Reversed.

A. The Examiner's Rejection

In the Final Office Action, the Examiner rejected claims 1, 2 and 15 under 35 U.S.C. § 103(a) as unpatentable over Delingette. (See 1/21/09 Office Action, pp. 2-3.) This rejection was restated in the Examiner's Answer. (See 9/10/09 Examiner's Answer, pp. 3-5.)

B. Delingette Does Not Disclose Or Suggest Means Of Locally Setting Higher Resolution When Reliable Image Features Are Found and Means of Setting Lower Resolution in the Opposite Case, As Recited In Claim 1.

Delingette describes a general tridimensional reconstruction algorithm of volumetric images, based on deformable simplex meshes. (See Delingette, Abstract.) In this paper, the author describes a refinement algorithm based on the minimization of a geometric criterion based on the distance to the data or the local curvature. (See id., p. 115, col. 1, ¶ 3.)

The simplex meshes are unstructured meshes, and can therefore be locally refined or decimated. (See id., p. 118, col. 2, ¶ 3.)

In the Appeal Brief, the Appellants argued that Delingette does not disclose or suggest setting a higher resolution when reliable image features are found and setting lower resolution in the opposite case, but, rather, discloses increasing resolution in areas of high curvature. (See 6/18/09 Appeal Brief, p. 4, citing Delingette, p. 121, Fig. 9b.) The Appellants further argued that Delingette's refinement measure is linked to the maximum distance to the data. (See 6/18/09 Appeal Brief, p. 4, citing Delingette, p. 133, col. 2, ¶ 5.) The Appellants further asserted that Delingette states that its algorithm is not sensitive to noise. (See 6/18/09 Appeal Brief, p. 4., citing Delingette, p. 127, col. 1, ¶ 2.) The Appellants concluded that Delingette does not disclose or suggest "means of locally setting higher resolution when reliable image features are found and means of setting lower resolution in the opposite case," as recited in claim 1. (See 6/18/09 Office Action, p. 5.)

In the Examiner's Answer, the Examiner asserted that the claim does not require any particular criteria to be met in order to qualify as "reliable image features," and, therefore, that any feature can qualify as a "reliable image feature." (See 9/10/09 Examiner's Answer, p. 13.) The Examiner further asserted that in extreme cases, high curvature values in noisy images could qualify as "reliable image features." (See id., p. 13.) The Examiner concluded by asserting that the fact that some high curvature regions are unreliable does not, by itself, exclude high curvature regions from being reliable. (See id., p. 13.)

However, even if the Examiner's arguments were assumed to be true, Delingette nonetheless does not disclose or suggest all claimed limitations. Claim 1 sets either a higher or a lower resolution, depending on whether reliable image features are found or not. In contrast, as discussed above, Delingette does or does not increase resolution in areas of high curvature. (See Delingette, p. 121, Fig. 9b.) Though, as the Examiner asserts, some high curvature regions may include reliable image features, Delingette nevertheless does not disclose any determination of whether to set a higher or lower resolution *on the basis of reliable image features*. The Examiner's only citation of Delingette on this issue merely points to a passage stating that simplex meshes can be locally refined or decimated, without providing any further explanation as to when it might be desirable to refine or decimate such meshes. (See 9/10/09 Examiner's Answer, p. 4, citing Delingette, p. 118, col. 2, ¶ 2; Table 5.) Therefore, the

Appellants maintain that Delingette does not disclose or suggest "means of locally setting higher resolution when reliable image features are found and means of setting lower resolution in the opposite case," as recited in claim 1. Accordingly, this rejection should be reversed. Because claim 2 depends from, and, therefore, includes all of the limitations of claim 1, it is respectfully submitted that this claim is also allowable.

The Appellants respectfully submit that Delingette does not disclose or suggest "locally setting higher resolution when reliable image features are found and setting lower resolution in the opposite case," as recited in claim 15, for the reasons discussed above with reference to claim 1. Accordingly, this rejection should be reversed.

II. The Rejection of Claims 3-7 Under 35 U.S.C. § 103(a) Over Delingette In View Of Bernardini Should Be Reversed.

A. The Examiner's Rejection

In the Final Office Action, the Examiner rejected claims 3-7 under 35 U.S.C. § 103(a) as unpatentable over Delingette in view of Bernardini. (See 1/21/09 Office Action, pp. 2-3.) This rejection was restated in the Examiner's Answer. (See 9/10/09 Examiner's Answer, pp. 6-8.)

B. Delingette And Bernardini Do Not Disclose Or Suggest Means Of Locally Setting Higher Resolution When Reliable Image Features Are Found and Means of Setting Lower Resolution in the Opposite Case, As Recited In Claim 1.

Bernardini discloses a method and apparatus for finding a triangle mesh that interpolates a set of points obtained from a scanner. (See Bernardini, col. 3, ll. 47-49.) Multiple scans of an object are aligned into a single coordinate frame, their points forming an unorganized point cloud. (See id., col. 6, ll. 5-7.) The disclosed ball-pivoting algorithm then connects these points as a series of triangles by "rolling" a ball of a given radius between the points. (See id., Abstract.) The algorithm continues until all the points in the cloud have been considered. (See id., Abstract.) The algorithm generates an output mesh that is a manifold subset of an alpha-shape of the point cloud. (See id., col. 5, ll. 33-35.) The alpha shapes are an effective tool for computing the "shape" of the point cloud. (See id., col. 7, ll. 18-19.) The final

output is a representation of the geometry of the scanned object in a computer model. (See id., col. 1, ll. 30-31.)

Bernardini considers sources of error in its measurement system. (See id., col. 1, ll. 41-53; col. 7, l. 24 - col. 9, l. 11). There are two sources of error: error in registration, and error along the sensor line of sight. (See id., col. 1, ll. 49-51.) Typical problems are missing points, non-uniform density, imperfectly aligned overlapping range scans, scanner line of sight error, and outliers. (See id., col. 8, ll. 12-20.) These are the problems that Bernardini considers "noise." Bernardini has ways of dealing with each problem. First, Bernardini discusses the holes created by "missing points." The points can be missing for several different reasons, including non-uniform density of the scanned point cloud, whether parts of the surface were not scanned, or when the points are missing because of some line of sight error. (See id., col. 8, ll. 5-11 and 26-57.) Due to these "noise" errors, certain parts of Bernardini's surface will be unreliable. In this situation, Bernardini teaches a method of filling these holes in, *increasing the resolution* in these areas, rather than decreasing the resolution. (See id., col. 8, ll. 44-57.) For instance, it describes a process of filling the holes in by applying the ball-rolling algorithm multiple times, increasing the ball radius each time. (See id., col. 8, ll. 44-48.) Second, Bernardini discusses the errors caused by improperly aligned overlapping scans. (See id., col. 8, l. 58 - col. 9, l. 6.) The noisy sample forms two layers, distant enough to allow the ball to walk on both layers. (See id., col. 8, ll. 60-62.) When Bernardini encounters this phenomenon, it *increases the resolution* of that noisy area by allowing the formation of undesired small connected components lying close to the main surface. (See id., col. 8, ll. 62-64.) Although the seed triangle selection process tries to avoid creating a large number of these small components, post-processing is required to remove them and smooth the surface. (See id., col. 8, l. 64 - col. 9, l. 6.) Finally, Bernardini discusses the problem of outliers. (See id., col. 8, ll. 15-20.) Bernardini suggests that outliers should be removed by the scanning device in pre-processing, thus simply *ignoring* this type of noise.

Thus, for these examples of unreliably noisy image features, the teachings of Bernardini would require either using a higher resolution, or simply ignoring the problem. In contrast, as described above, claim 1 recites "setting higher resolution when reliable image features are found and *means of setting lower resolution in an opposite case*." That is, setting a lower resolution when reliable image features are not found.

Therefore, Appellants respectfully submit that Bernardini does not cure the deficiencies of Delingette discussed above with reference to claim 1, and that Delingette and Bernardini, alone or in combination, neither disclose nor suggest "means of locally setting higher resolution when reliable image features are found and means of setting lower resolution in an opposite case," as recited in claim 1. Since claims 3-7 depend from claim 1, the rejections of these claims should be reversed for at least the foregoing reasons.

III. The Rejection of Claims 3-7 Under 35 U.S.C. § 103(a) Over Delingette In View Of Bernardini and Vannah Should Be Reversed.

A. The Examiner's Rejection

In the Final Office Action, the Examiner rejected claims 8-14 under 35 U.S.C. § 103(a) as unpatentable over Delingette in view of Bernardini and in further view of Vannah. (See 1/21/09 Office Action, pp. 2-3.) This rejection was restated in the Examiner's Answer. (See 9/10/09 Examiner's Answer, pp. 8-12.)

B. Delingette, Bernardini And Vannah Do Not Disclose Or Suggest Means Of Locally Setting Higher Resolution When Reliable Image Features Are Found and Means of Setting Lower Resolution in the Opposite Case, As Recited In Claim 1.

Vannah discloses a method and apparatus for determining and recording the 3-D topography of various scalar properties of objects, such as organs in the body. (See Vannah, col. 3, ll. 8-10). Vannah assigns each sample data point to a compartment within the computer model. (See id., col. 3, ll. 15-24; col. 4, ll. 53-61.) A quality value for each sample point is determined, based on the quality of the signal, and these quality values are recorded in the compartments. (See id., col. 3, ll. 24-28.) The algorithm then recalculates the data points when the quality value indicates that it is unacceptable, and assigns a new quality value. (See id., col. 3, ll. 28-35.) The steps are repeated until all the compartments have an acceptable quality value. (See id., col. 3, ll. 35-40.)

Vannah considers the quality of the data it measures. "Quality is defined in terms of accuracy and quantity of the sampled data." (Id., col. 4, ll. 45-47.) Quality is low

when there are widespread discrepancies between sampled points in a given region, or when there are too few sampled points in a given region. (See id., col. 4, ll. 47-51.) When Vannah encounters the problem of low quality, it directs the operator to obtain more samples in those areas, thereby *increasing the resolution*. (See id., col. 4, l. 66 - col. 5, l. 1.) Specifically, Vannah notes that noisy, poor quality areas are heavily corrected, and high quality areas are minimally corrected. (See id., col. 5, ll. 16-19.)

Thus, for these examples of noisy, poor quality image features, the teachings of Vannah would require either using a higher resolution. In contrast, as described above, claim 1 recites "setting higher resolution when reliable image features are found and *means of setting lower resolution in an opposite case*." That is, setting a lower resolution when reliable image features are not found.

Therefore, Appellants respectfully submit that Vannah does not cure the deficiencies of Delingette and Bernardini discussed above with reference to claims 3-7, and that Delingette, Bernardini and Vannah, alone or in combination, neither disclose nor suggest "means of locally setting higher resolution when reliable image features are found and means of setting lower resolution in an opposite case," as recited in claim 1. Since claims 8-14 depend from claim 1, the rejections of these claims should be reversed for at least the foregoing reasons.

4. Conclusion

For the reasons set forth above, Appellant respectfully requests that the Board reverse the rejection of the claims by the Examiner under 35 U.S.C. § 103(a), and indicate that claims 1-15 are allowable.

Respectfully submitted,

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CLAIMS APPENDIX

1. (Previously Presented) An image processing system having image data processing means of automatic adaptation of 3-D Mesh Model to image features, for Model-based image segmentation, comprising means of dynamic adaptation of the Model resolution to image features including means of locally setting higher resolution when reliable image features are found and means of setting lower resolution in the opposite case; and comprising viewing means for visualizing the images.

2. (Previously Presented) The system of claim 1, having data processing means to define a feature confidence parameter for each image feature, and to locally adapt model resolution according to it.

3. (Previously Presented) The system of claim 2, having data processing means to define a feature confidence parameter as a parameter that depends on the feature distance and on the estimation of quality of this feature including estimation of noise, and having data processing means to penalize the large distances and the noisy, although close features.

4. (Previously Presented) The system of claim 3, having data processing means for decreasing the resolution of the Model in absence of confidence and gradually increasing the resolution of the Model with the rise of feature confidence.

5. (Previously Presented) The system of claim 4, having data processing means for causing low local resolution to constrain local surface curvature, for preventing the model surface from self-intersections.

6. (Previously Presented) The system of one of claims 1 to 5, having means to make feature confidence available for model adaptation, comprising means to display the Model regions with different colors representing the confidence at the location of said regions for the user to supervise the deformation process of the Model and to locally assess its final quality.

7. (Previously Presented) Image processing system of claim 6, for the segmentation of a three

dimensional object in a three dimensional image including data processing means for mapping a three dimensional mesh model onto said three dimensional object comprising means for: Acquiring a three-dimensional image of an object of interest to be segmented, generating a Mesh Model, formed of polygonal cells and deforming the Mesh Model in order to map said Mesh Model onto said object of interest.

8. (Previously Presented) The image processing system of claim 7, further comprising means for: Constructing a Color Coding Table wherein predetermined colors are associated to given confidence parameter values; Associating the confidence parameter values of a given cell of the Mesh Model to a color given by the color coding Table corresponding to said confidence parameter values.

9. (Previously Presented) The image processing system of claim 8, further comprising data processing means for: Performing a color coding operation by attributing to said given cell, the color determined from the Color Coding Table, corresponding to the confidence parameter values; and display means for: Displaying the image of the Mesh Model having cells colored according to the color-coding operation.

10. (Previously Presented) The image processing system of claim 9, wherein the color-coding operation is performed for all the cells or for a predetermined number of cells.

11. (Previously Presented) The image processing system of claim 10, further comprising means for: Taking a decision to stop the process of mapping the Mesh Model onto the object of reference in function of a predetermined confidence level.

12. (Previously Presented) A medical imaging system comprising a suitably programmed computer or a special purpose processor having circuit means, which are arranged to form an image processing system as claimed in claim 11 to process medical image data; and display means to display the images.

13. (Previously Presented) A medical examination imaging apparatus having: Means to acquire a

three-dimensional image of an organ of a body, and a medical imaging system according to claim 12

14. (Previously Presented) A computer readable medium storing a program to control a system, said program comprising a set of instructions to be used in the system as claimed in claim 11.

15. (Previously Presented) An image processing method, comprising steps of: acquiring image data of a 3-D image with image features, and automatically adapting 3-D Mesh Model to image features, for Model-based image segmentation, whereby: dynamically adapting the Model resolution to image features including locally setting higher resolution when reliable image features are found and setting lower resolution in the opposite case; and comprising steps of visualizing the images.